A recent research project that compared the effects of shot peening to laser peening on welds is a tribute to Henry O. Fuchs

Weld Fatigue Research

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Fatigue and fracture mechanics are two of his special fields of knowledge and he has done extensive research on the fatigue behavior of cast steel, the influence of high mean tensile stress on fatigue life, and the influence of residual stress and mean stress on bolted and welded fasteners.

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I presented this paper at ICF12 in July. I chose to work on this project for two reasons: First, the research is part of our SAE Fatigue Design Evaluation (SAEFDE) weld program that holds wide interest in SAE. Second, this is my last research project prior to my phased retirement and I wanted to honor Henry O. Fuchs—my good friend and co-author of our book, *Metal Fatigue in Engineering*.

Henry died in 1989 but his contributions live on in the SAEFDE. He co-led one of most popular short courses in SAE history. The course, titled *Fatigue Concepts in Design*, ran for 30 years and had more than 2,000 participants. His work in fatigue studies was so important that SAE gives the H.O. Fuchs award annually to a deserving student in fatigue research.

Henry's contribution extended beyond the academic. He started Metal Improvement Company in his garage in the 1950s and this company has grown to be one of the largest shot peening companies in the world.

I always considered Henry to be "Mr. Residual Stress," a title I passed down to him after John O. Almen passed away. Thus, based on Henry's strong influence in shot peening and residual stresses, I did this research project to honor my dear colleague and friend. The ICF12 presentation will most likely be my last professional presentation on fatigue.

—**Professor Ralph I. Stephens**

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Effect of Shot and Laser Peening on SAE 1010 Steel Tubes with a Transverse Center Weld Subjected to Constant and Variable Amplitude Loading

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INTRODUCTION

Compressive surface residual stresses from shot peening have proven to be extremely beneficial to fatigue resistance of intermediate and high strength metals and alloys. Lower strength materials, including steel weldments, often are believed to not have this significant benefit. This is due to lower yield strengths that restrict the magnitude of induced residual stresses and the relaxation of residual stresses during cyclic loading due to local plasticity. Thus, the application of shot peening, or emerging laser peening, has not been common in steel weldments with yield strengths less than about 400 MPa. The limited research available in the literature concerning these lower strength mild steel weldments, however, has indicated increased constant amplitude fatigue limits at $2x10^6$ cycles of between 10 to 90%.[1-4] Most of these tests were performed with an R-ratio (S_{min}/S_{max}) equal of 0 or 0.1, and included longitudinal and transverse fillet welds, butt welds and bead-on-welds. Intermediate fatigue lives often showed mixed results, whereas at shorter life ($\leq 4x10^4$ cycles), no benefits from shot-peening were obtained. Laser peening produces deeper penetration of compressive residual stresses than shot peening and hence may produce better fatigue resistance than shot peening for mild steel weldments. Laser peening has been very successful in higher strength materials involving aluminum, steel and titanium alloys.[5,6] However, it is significantly more expensive than shot peening. The goals of this research were to compare the fatigue resistance of both shot and laser peened mild steel weldments under constant and variable amplitude loading as part of the Society of Automotive Engineers Fatigue Design and Evaluation (SAEFDE) committee's fatigue of weldments program.

DISCUSSION OF RESULTS

The literature review indicated shot peening of mild steel weldments increased the constant amplitude R = 0 or 0.1 fatigue strength at $2x10^6$ cycles by 10 to 90% with little increase at intermediate or low cycles to failure. However fatigue behavior under variable amplitude or other R ratios was not found. Thus, ambiguity exists as to how beneficial shot peening can be in low strength steel weldments. This research confirmed the beneficial effects of both shot and laser peening on constant amplitude R = 0.1 and 0.5 fatigue strengths at $2x10^6$ cycles, with little benefit at shorter lives. However, under three different variable amplitude spectra little influence on fatigue life was found with either shot or laser peening. This beneficial or little effect is usually attributed to whether or not the desirable residual compressive stresses are maintained or relaxed during cycling in these low yield strength weldments. The laser peened and shot peened weldments had similar near surface residual compressive stresses, but the laser peened residual stresses remained compressive to much greater depths. This greater depth was only beneficial with respect to shot-peening for the R = 0.1 tests. The macro and micro hardness values indicated surface and depth hardness was greater for the laser peened specimens. All test conditions had little scatter with cracks nucleating at the root of the starting weld area. Fatigue crack growth regions had the same morphology at both the macro and micro levels for the three test conditions as did final fracture regions.

CONCLUSIONS

Both shot and laser peening caused increased fatigue strengths in these mild steel weldments at 2x10^6 cycles with R = 0.1 and 0.5, but had little effect at shorter lives and with three different variable amplitude tests. The greater depth of compressive residual stresses and micro hardness from laser peening was beneficial with respect to shot peening for only R = 0.1 tests at long life. The current additional cost for laser peening of mild steel weldments would not yet be justifiable.

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